GAULT BRIDGE
SOUTH PINE STREET crossing DEER CREEK
NEVADA CITY
NEVADA COUNTY
CALIFORNIA

HAER No. CA-158

HAER
CAL
29-NEVCI,
6-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
NATIONAL PARK SERVICE
WESTERN REGION
DEPARTMENT OF THE INTERIOR
SAN FRANCISCO, CALIFORNIA 94107

HAER
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HISTORIC AMERICAN ENGINEERING RECORD

Gault Bridge
Nevada City, Nevada County, California
HAER No. CA-158

Location: Crossing Deer Creek in Nevada City, Nevada County, California following the alignment of Pine Street from downtown commercial district to the Piety Hill residential area and south to Grass Valley.

Quad: Nevada City, CA, 7.5 '
UTM: 10 E: 670977
N: 43477292

Date of Construction: 1903

Designer: American Bridge Company

Builder: Clark and Henery, Stockton, CA

Present Owner: City of Nevada City

Original Use: Vehicular and Foot Bridge

Present Use: Vehicular and Foot Bridge

Significance: The Gault Bridge has been determined eligible for the National Register of Historic Places under criterion c for its significance in the history of bridge technology in California (Caltrans Bridge Inventory #17C-01). The Gault Bridge is the oldest three-hinge, steel arch bridge in California, and a rare, surviving example of this type of bridge construction. Designed by the American Bridge Company, the Gault Bridge was erected in 1903 by Clark and Henery, a Stockton, California contracting firm.

Report Prepared By: Ward Hill
Architectural Historian
3124 Octavia Street
San Francisco, CA 94123

Date: October, 1994

I. Description

The Gault Bridge spans a moderately steep canyon adjacent to Deer Creek which runs through Nevada City. The south approach to the Gault Bridge is on a steep hill through a densely built-up 19th century residential district. By contrast, the north approach to the bridge is through a densely wooded hill with a few scattered houses. The visibility of the northern approach to the bridge is especially restricted because the road takes a sharp turn to the east just before the bridge approach. A high concrete retaining wall and sidewalk along the west side of the northern approach was constructed at the same time as the bridge. Much of the bridge is now obscured by a number of large trees and a variety of foliage.

The north and south abutments of the Gault Bridge are constructed of large blocks of dressed granite. The larger abutment stones are over 4 feet in length and 1.5 feet wide. The granite in the south abutment is partially encased on the sides in reinforced concrete. The additional concrete work on the south was for supporting the roadbed at the point the bridge joins the hillside. Rising from a base (at grade) about 19 feet wide, the battered walls of the abutments are approximately 14 feet tall.

The total length of the Gault Bridge is 300 feet. The bridge is constructed in three parts - at the north and south ends, individual structures or towers with timber stringers and steel trestle bents, are independent of the central steel arch. The 150 foot main span or arch supports both sides of the 18.25 foot wide two-lane roadway. The arch and roadway are joined by a riveted Pratt truss. The truss' vertical members vary in length from 34 feet to 6.5 feet, while the diagonal members are from 28.4 feet to 16.4 feet. The three-hinge design of the arch includes a hinge or pin at the foundation footings on each side of Deer Creek, and one hinge at the center span. A distinguishing feature of the bridge is the lattice bracing of the superstructure.

Adjacent to the asphalt paved roadbed is a four foot wide, wood plank pedestrian sidewalk, separated from the roadway by a concrete curb with a metal abutment and a low wooden fence. The bridge is notable for the steel railing that runs along the wood-plank pedestrian sidewalk on the west side of the bridge and adjacent to the roadway on the east side of the bridge. The lacy geometric design and the ornamental newel posts at the two bridge approaches are distinguishing features of the railing. The classically detailed newel posts (at the north and south ends of the sidewalk) have a base and capital with an abstract, inlaid floral design, a fluted shaft and a moulded top cap.

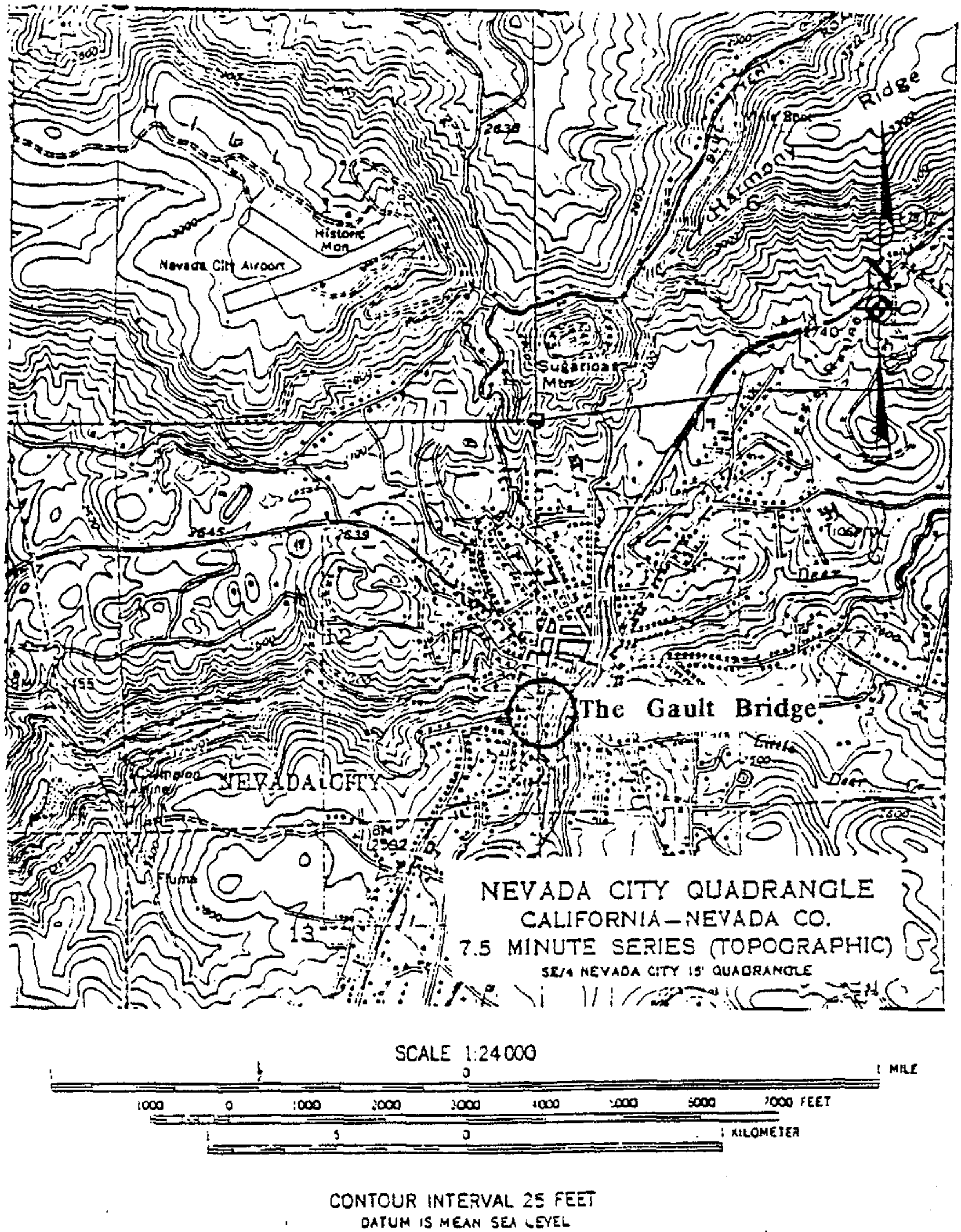

Figure 1: Gault Bridge Location Map

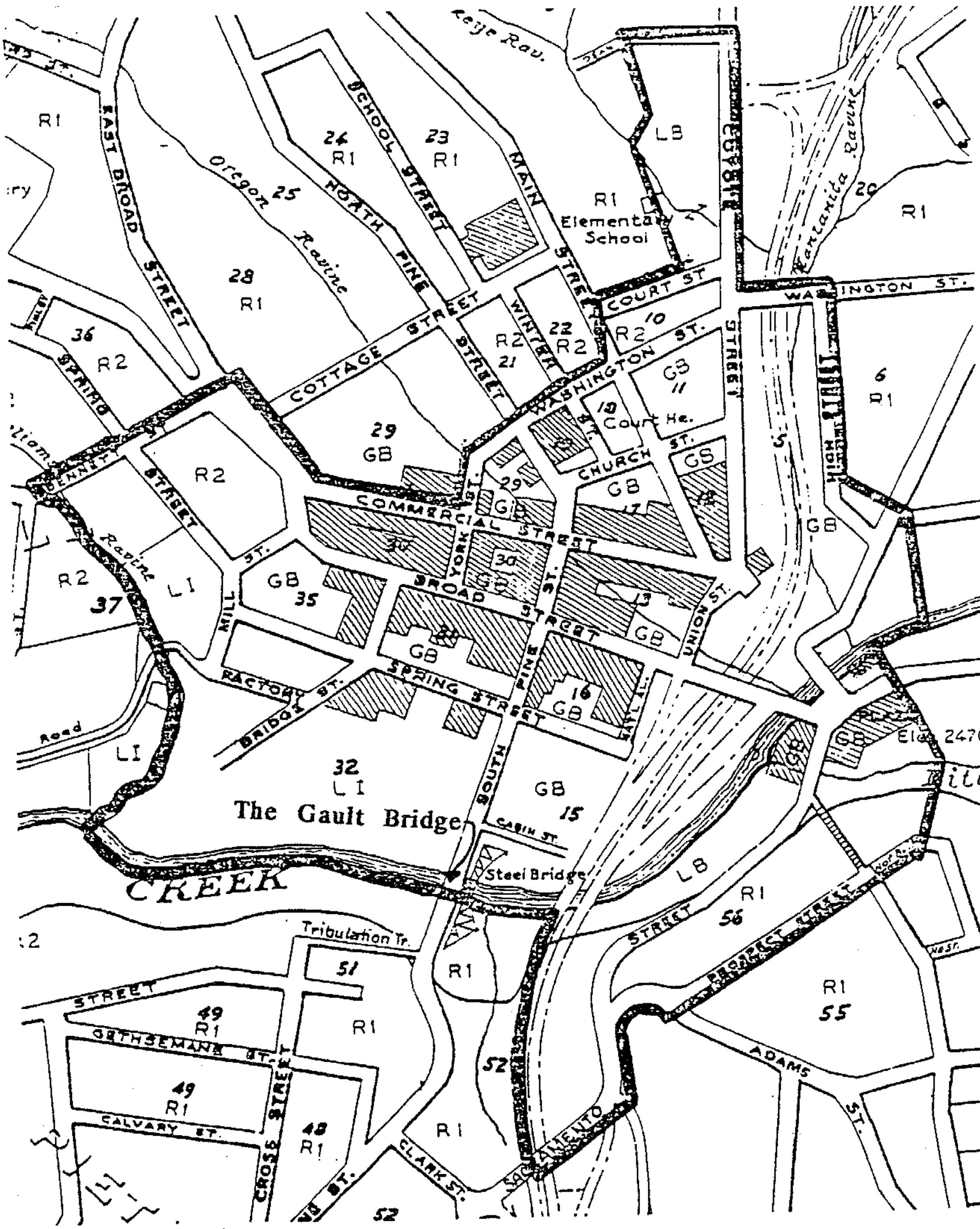

Figure 2: Nevada City Map showing location of Gault Bridge
(downtown historic district outlined in black)

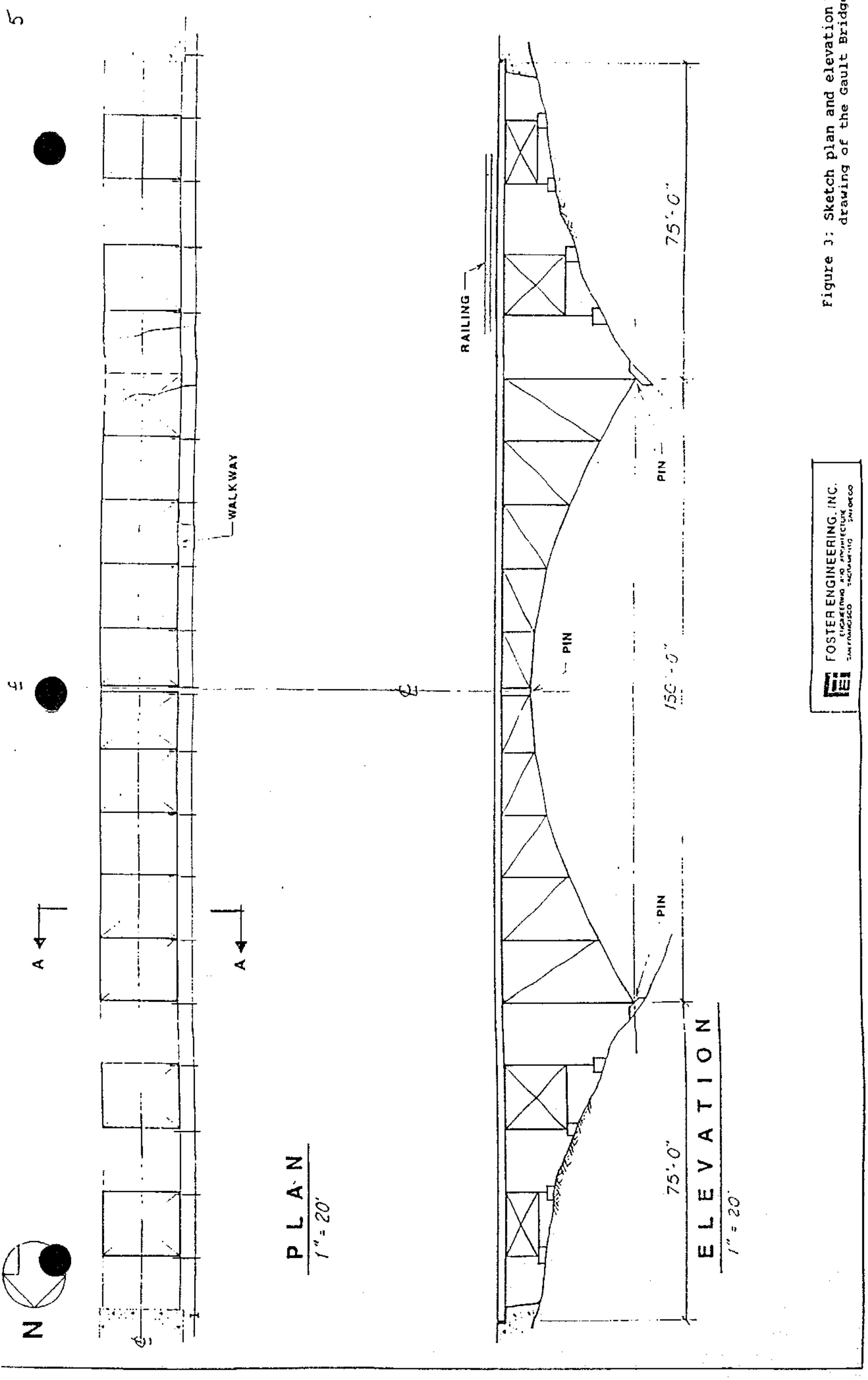

Figure 3: Sketch plan and elevation drawing of the Gault Bridge

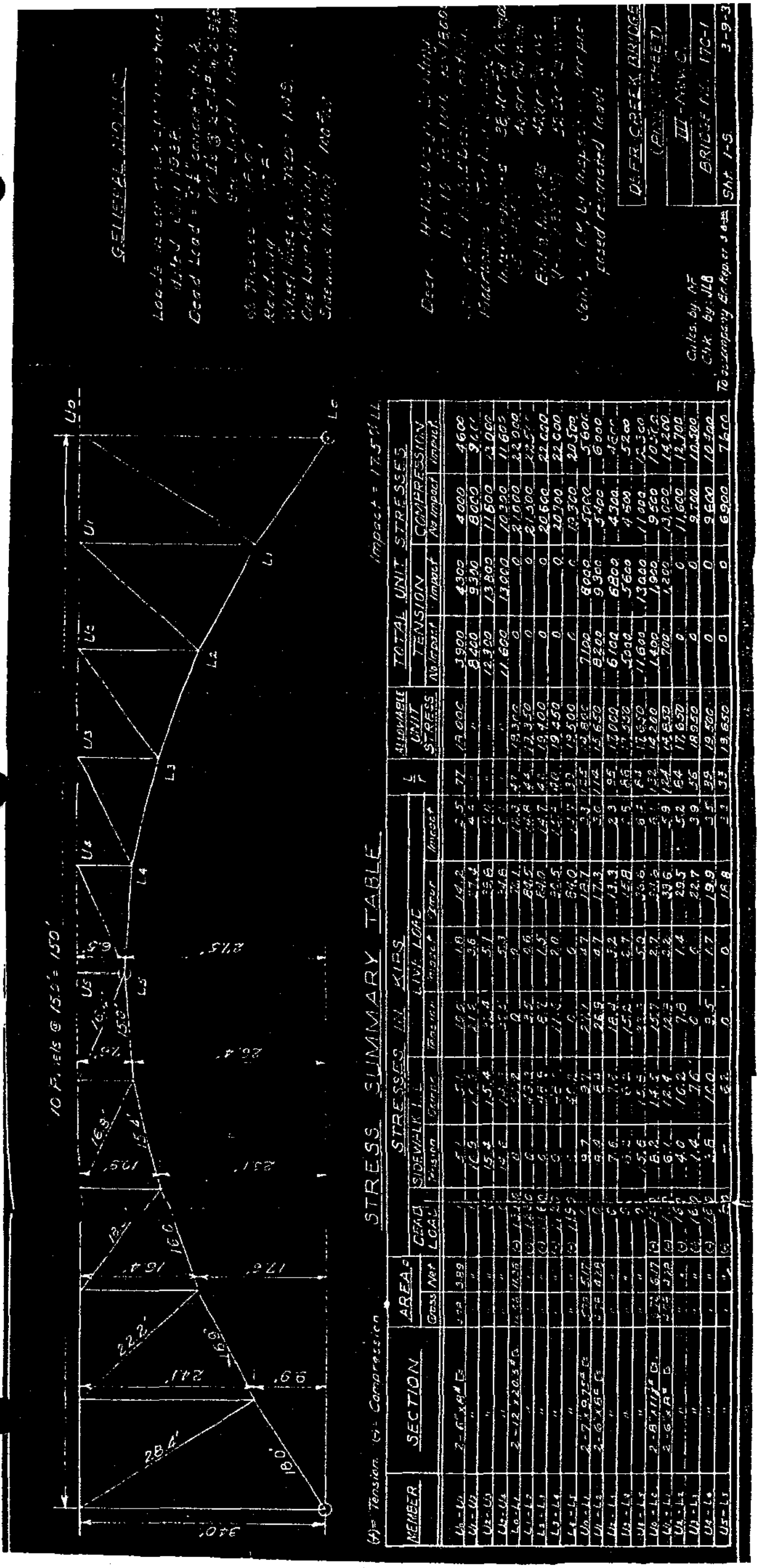

Figure 4: Stress Summary Table of the Gault Bridge's center arch (prepared by California Division of Highways, 1939 based on original bridge specifications)

II. Historical Context

A. Early Truss and Metal Arched Bridges in the United States

The truss bridge - any bridge whose individual members are connected in a triangular pattern - dates back to at least the Renaissance in Europe. The earliest iron truss bridges in the United States were initially built primarily for the railroads during the 1840s. Metal truss bridges were recognized as ideal for supporting the weight of a roadway across a canyon or abyss because the road's weight puts the vertical bars in compression and the diagonals, subject to stretching, in tension. The forces balance, the truss remains rigid, and the road is supported. Important American pioneers in the development of truss bridge types were Squire Whipple, inventor of the Whipple truss, and Caleb and Thomas Pratt, inventors of the Pratt truss. Whipple was especially important in developing a scientific basis for truss bridge design, enunciated in his influential 1847 book, *A Work on Bridge Building*, where he analyzed the stresses in the articulated truss. [1] Patented in 1844, the Pratt truss, composed of alternating vertical and diagonal members, became by far the most common truss form in the United States and in California. [2] The arch of the Gault Bridge was built with a Pratt truss.

The first major steel arched bridge in the United States was built between 1867 and 1874 in St. Louis over the Mississippi River. Designed by James B. Eads, the "Eads bridge" is composed of three adjacent, 500 foot fixed arches, a form adopted "because of its familiarity and rigidity." [3] The fixed arch, however, had limited

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[1] David Steinman & Sarah Watson, *Bridges and their Builders* (New York: G.P. Putnam's Sons, 1941), p. 160.

[2] see Carl Condit, *American Building* (University of Chicago Press, Chicago, Ill.,1968), page 96. The California Historic Bridge Inventory identified 137 Pratt truss bridges, the most common type of truss highway bridge in California. David Weitzman notes in his book *Traces of the Past* (page 73) that the famous bridge engineer J.A.L. Waddell observed in 1884 "that at least ninety percent of all American iron highway bridges then being built were either of Pratt or Whipple design, a trend which had apparently continued throughout the decades after the Civil War."

[3] Condit, page 151.

applications in situations where asymmetrical and other unusual forms were needed. By introducing hinges into the crown and springing points of the arch, the indeterminacy of the fixed arch, i.e. the difficulty of calculating its abutment reactions and the compression stresses on the arch itself, were remedied. By dividing the arch into free halves, the forces acting on the hinges can be exactly calculated, and each segment can be fabricated so that the lower rib conforms more nearly to the curve of the pressure line.

Developed by various French and German engineers in the late 1850s and early 1860s, the three-hinged arch was not introduced to the United States until 1867 by Joseph M. Wilson, who proposed its use for a train shed for the Pittsburgh station of the Pennsylvania Railroad. [4] The railroad company rejected the proposal as too expensive, but Wilson later designed the first three-hinged arch bridge in the United States over 13th Street in Philadelphia for the Pennsylvania Railroad in 1869. Condit describes this bridge as having a

> multitrack deck supported by twelve parallel wrought-iron ribs spanning 64 feet clear. The load was carried to the ribs by spandrel trusses in the form of the Pratt truss with pinned connections. [5]

Condit notes that Wilson chose this form not only because of the benefits of the determinate structure of the three-hinged arch, but because of its "greater flexibility to compensate for secondary stresses caused by thermal expansion and contraction." [6]

As the weight of trains increased during the 19th century, the three-hinged arch was considered to be too flexble for rail bridges, resulting in its use being confined to lighter highway bridges, like the Gault Bridge. Nevertheless, Hool and Kinne pointed out in 1923 that the "three-hinged type has been by far the

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[4] Condit, page 135.

[5] Condit, page 151.

[6] Condit, page 151. Hool and Kinne note in their 1923 book on bridge design, *Movable and Long-Span Steel Bridges* (McGraw-Hill Book Company, New York), that the principal disadvantage of three-hinged arch bridge is its "lack of rigidity." They also note the advantage of this bridge type "lies in its freedom from temperature stresses and in the fact that vertical and lateral movements of the supports, unless they be of considerable magnitude, will not induce any material stress in the superstructure" (page 362).

most extensively used type of structure in America." [7] The three-hinged arch was recognized as a particularly appropriate highway bridge for natural settings because the arch was considered "inherently attractive in form," and the determinancy of this bridge type allowed the designer to use smaller and fewer members, thereby reducing the obstruction of those viewing the natural surroundings. [8] Henry Grattan Tyrrell notes in his 1911 *History of Bridge Engineering* that the Canadian Pacific Railroad had built a number of attractive three-hinged arch railroad bridges in rocky and steep, but "very picturesque", mountain areas of British Columbia during the 1890s. [9] Apart from its potential aesthetic merits, Hool and Kinne also point out that "arches in general" are "most adaptable to deep, rocky ravines where ample head room can be secured, and where natural foundations of the best are encountered." [10]

B. Truss and Metal Arched Bridges in California

Like the rest of the United States, the truss bridge was originally built for the railroads in California. During the 1880s, California's counties began to take a more active role in highway bridge building, and the first metal truss highway bridges, essentially variations on railroad bridge designs, were constructed. These early bridges were typically built in the more remote areas of the Coast Range Mountains or in the Sierra Nevada foothills by California-based companies that did not specialize in bridge building. The early metal truss bridge builders in California designed and built bridges as a sideline, with their main business being some other area of metal fabrication (such as mining equipment or agricultural equipment). The truss designs by these California-based firms tended not to be very innovative versions of common truss forms developed by East Coast engineers.

After its organization in 1900, the American Bridge Company became an important force in California bridge design. The company was originally organized by J.P. Morgan and Company, but most of its

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[7] Hool and Kinne, page 363.

[8] David A. Simmons, "Art and Engineering Combined in Springfield Bridge," *Ohio County Engineer*, Summer, 1990, page 19.

[9] Tyrrell, pages 329-330.

[10] Hool and Kinne, page 363.

stock was purchased by U.S. Steel within a year. [11] During its first year after incorporation, the American Bridge Company purchased 24 companies (all in the northeast and midwest) representing 50 per cent of the bridge fabricating capacity in the United States. In 1903, the company completed a huge plant in Ambridge, Pennsylvania (near Pittsburgh) which had the fabricating capacity of the five largest companies purchased by American Bridge. The company soon dominated truss bridge fabrication throughout the United States. According to the Caltrans Bridge Inventory, of the extant trusses in California for which a builder is known, American Bridge was responsible for 25 per cent of those built between 1900 and 1910, 37 per cent of those built between 1911 and 1920, and 45 percent of those built in the 1920s. [12] Between 1900 and the 1920s, the truss bridge was gradually replaced by the reinforced concrete arch bridge because it was considered to be aesthetically superior and easier to maintain. By the 1930s, "the truss bridge was used very rarely for ordinary bridges -- fixed bridges of small to moderate length." [13]

Although common in the eastern United States, the three-hinge arched truss bridge was a form rarely used in California. According to the 1985 Caltrans Bridge Inventory, only two examples of the three-hinge arch bridge survive in California from the period 1900 to 1930. The Gault Bridge is one example, and the other is the nearby 1904 Edwards Bridge, also designed by the American Bridge Company, built over the South Fork of the Yuba River. With its graceful arch and light, delicate truss members, the Edwards Bridge achieves the ideal of the three-hinge arch open to its natural surroundings. Likewise, the Gault Bridge "represents a very successful attempt to integrate a truss bridge into a sensitive rural environment." [14] Several three-hinge arch bridges survive in California from the 1930s, one of which has achieved particular distinction. Designed in 1931 by John T. Shaw, onetime Los Angeles City Engineer, the First Avenue Bridge in San Diego, a metal truss three-hinge arch bridge, has been recognized as "one of the most

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[11] Victor C. Darnell, *Directory of American Bridge Companies: 1840-1900* (Society of Industrial Archeology, Washington, D.C., 1984), page 85.

[12] California Department of Transportation, *Request for Determination of Eligibility for the National Register of Historic Places -- Historic Truss Bridges of California*, 1985, page, 16.

[13] California Department of Transportation, page 17.

[14] California Department of Transportation, page 21.

beautiful truss bridges in California."[15]

C. The Design and Construction of the Gault Bridge

A few months after California became a U.S. territory in 1848, John Marshall discovered gold at Sutter's Mill in Coloma and the California Gold Rush began. The Gold Rush reached Nevada City in 1849 when gold was discovered in Deer Creek. Nevada City was founded in 1850, and it became the county seat in 1851 when Nevada County was formed. The area experienced phenomenal growth because of the influx of people engaged in surface placer mining. By 1856, the Nevada City vicinity had a population of 8,000. During the election of 1856, Nevada City polled 2,082 votes, exceeded in California only by Sacramento and San Francisco (Nevada City Chamber of Commerce 1972:2).

The rapid growth in Nevada City in the early 1850s led to the construction of houses outside of the central commmercial district near Broad Street. The first bridge over Deer Creek at Pine Street was constructed in 1853 linking the downtown with an early residential area known as Piety Hill south of Deer Creek. This small suspension bridge built by the county over Deer Creek was damaged by flood and hard service by 1860. [16] A second suspension bridge designed by a 25 year old engineer named Andrew Hallidie was constructed in 1862. [17] An inventor of different types of wire rope

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[15] Caltrans, *Historic Highway Bridges of California*, page 173.

[16] see "From Here to the Cable Cars" in *Gold Cities - Grass Valley & Nevada City* by Jim Morley and Doris Forley (Howell North, Berkeley), 1965; and "Nevada City Played a Vital Role in Bridge Evolution in State," by Al Trivelpiece in *100 Years of Nevada County* (Nevada City Nugget), May 18, 1951.

[17] Halladie was born in Scotland in 1836, the son of an inventor and engineer. He immigrated to California in 1852, and he first worked with wire cable in 1856, spinning a cable for pulling ore carts. In 1857, Hallidie established the first wire cable manufacturing facility in California. Hallidie designed seven suspension bridges using his wire cable in the early 1860s, none of which survive. During the remainder of the 19th century, very few suspension bridges were built in California after Hallidie stopped designing them in the early 1860s. Nevertheless, Hallidie manufactured wire cable in San Francisco, and experimented with new applications for the product, until his death in 1900. See

Hallidie used 1,050 separate 12-gauge wires for the two four inch diameter cables on the Nevada City bridge. The fourteen foot wide bridge deck and the towers carrying the cables were made of wood timbers. [18] A few months after opening in May, 1862, the bridge collapsed because one of the bulkheads gave way, killing 2 men and fifteen oxen. After considerable strengthening and rebuilding under Hallidie's supervision, the bridge was reopened in October, 1862. Hallidie later used his wire rope for his most famous invention, the world's first cable car line, constructed in San Francisco in 1873.

Despite its inauspicious beginning, the rebuilt Hallidie bridge over Deer Creek survived for almost forty years until it was considered unsafe in 1901. On August 22, 1901, the Nevada City Board of Trustees voted to close the Pine Street bridge because its wooden structural members had become too deteriorated. A petition was presented to the Board of Trustees at their February 20, 1902 meeting on behalf of the taxpayers of Nevada City asking the city to replace the suspension bridge "now spanning Deer Creek, and which has been declared unsafe for traffic, with a substantial structure." [19] As a result of this petition, the Board voted to place an ad in the local newspapers requesting bids for plans and the construction of a replacement bridge. The public advertisement for the construction of a new bridge published for five weeks specified that "the abutments now in place [should] be used, the distance between the abutments was 300 feet, and that the bridge width should be sixteen feet with a four foot walkway on the west side." [20]

Three construction companies - American Bridge Company, Clark and Henery and Clinton Bridge Company - presented plans to the Board on April 9, 1902. Representatives of the American Bridge Company and Clark and Henery also made presentations to the Board regarding their plans. According to the April 10, 1902 *Daily Morning Union*, "the city hall was crowded with interested spectators who carefully scanned the three sets of plans." The Board voted to accept the

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California Department of Transportation, Request for Determination of Eligibility for Inclusion in the National Register of Historic Places: Historic Bridges in California, pages 37-39.

[18] Teivelpiece op. cit. p. 72.

[19] Minutes of Nevada City Board of Trustees meeting, February 20, 1992.

[20] Nevada City Board of Trustees minutes, February 24, 1902.

American Bridge Company plans and to advertise for bids for the construction of the bridge according to these plans. The *Daily Morning Union* indicated that the American Bridge Company's plans "seemed to be the most admired," and that the arched structure "would be most imposing," and "an ornament to that part of the city." [21]

The Board of Trustees held a special meeting on May 12, 1902 "for the purpose of receiving and opening bids for the erection of a new steel bridge to span Deer Creek." [22] Seven companies submitted bids for the erection of the new bridge:

Healy and Tibbetts	$ 12,262
Loudon Bridge Company	13,879
Cotton Brothers	10,167
Blodgett & Company	10,800
Clark & Henery	10,143
American Bridge Company	10,934
Clinton Bridge	10,200

The Board voted to award the contract to the lowest bidder, Clark & Henery of Stockton, California, and to pay American Bridge Company one percent of the contract amount (i.e. one percent of $10,143 or $101.43) for their plans and specifications. The contract between Clark & Henery and Nevada City was approved the next day on May 13, 1902.

After the contract was signed, Clark & Henery had to petition the Board twice for an extension of time to complete the bridge because of delays in securing the metal from the East Coast. Exactly one year after the Board of Trustees had awarded Clark & Henery the contract, the May 12, 1903 *Daily Morning Union* reported that "the first real work", the construction of a column on the south side of the creek, had commenced for the new bridge. The work of demolishing the old bridge occurred while the new bridge was under construction. The Board approved selling the wire cable from the old bridge to Ben Heall for $5.00. Eugene Goldsworthy, the Superintendent in charge, estimated that work on the arch over the creek would begin about a week after the beginning of construction. [23] At their May 14, 1903 meeting, the Board of Trustees agreed to pay

[21] "Plans for New Steel Bridge," *Daily Morning Union*, pg. 4.

[22] Nevada City Board of Trustees meeting minutes, May 12, 1902.

[23] "Progress of Bridge Work," *Daily Morning Union*, May 14, 1903, page 5.

Clark & Henery fifty percent of the contract amount given that the bridge materials had been delivered and construction had begun.

Approximately two months after construction had begun on the bridge, Goldsworthy reported to the Board of Trustees on July 14, 1903 that the bridge had been completed according to contract. The July 19, 1903 *Daily Morning Union* reported that the "completed structure is in every way superior and safer than the old suspension bridge." [24] The Board of Trustees officially accepted the new bridge as completed and approved final payment to the contractor on August 13, 1903. A separate contract with J.W. Brady was approved on July 27, 1903 for the construction of the south abutment wall and approach to the new bridge. [25] The Gault Bridge was named after Alex Gault, the mayor of Nevada City who died soon after the bridge's completion.

D. Alterations to the Gault Bridge since 1903

The Gault Bridge has received only minor alterations since originally constructed in 1903. The original structural steel has remained intact. The most significant alterations have been made to the materials and width of the roadbed. When first constructed, the roadway was covered with only wood planks nailed to the wood stringers. The bridge had no curbing, and there was no barrier separating the sidewalk from the roadway. The bridge was closed temporarily in 1920 because the planks had become so worn and deteriorated.[26] The larger planks and stringers used to repair the bridge in 1920 increased its loading capacity.

The first inspection report of the Gault Bridge by the California Division of Highways in 1928 recommended rebuilding the entire roadway with new flooring, stringers and a one inch macadam wearing surface. The report indicated that many of stringers not replaced in 1920 were in poor condition. Apparently, no repairs had been made as of the date the state's second report on the bridge in 1932. This report indicated that "the plank floor is now loose and

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[24] "Contractors Complete Their Work," *Daily Morning Union*, July 19, 1903, page 6.

[25] Nevada City Board of Trustees meeting minutes, July 27, 1903.

[26] "Pine Street Bridge will be Repaired during the Next Week," *The Daily Morning Union*, September 17, 1920, page. 4.

in poor condition. The light mastic surfacing is rough due to this loose floor condition." [27] The 1932 report also recommended rebuilding and widening the roadway to 18.25 feet by cantilevering the sidewalk off the west side of the bridge so the roadway and curbs would occupy the entire width (20 feet) of the superstructure. The widening of the roadway finally occurred in 1941.[28] The roadway was also resurfaced with concrete and asphalt, and concrete curbs were installed. Projecting steel I-beams, with steel diagonal supports connected to the bridge's columns and trusses, were constructed to carry the sidewalk's wooden stringers off the west side of the bridge. The original western bridge railing was retained on the new cantilevered sidewalk. The wood fence today separating the sidewalk from the roadway appears to date from the last 10 years. The bridge has not been altered significantly since 1941.

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[27] California Division of Highways, *Report on Nevada City Bridge across Deer Creek at Pine Street*, June, 1932, page, 2.

[28] California Department of Transportation, *Gault Bridge Report*, June 10, 1975.

Nevada City Aug. 13-1903

Special meeting of the Board of Trustees called by the President
All the members being present President Chapman presiding

The object of this said meeting was for the purpose of acting on the acceptance of the new steel bridge on Pine street spanning Deer Creek And other business coming before it.

A motion was moved and carried that this said Bridge be accepted by this Board of Trustees and a warrant drawn on the General fund for 1/4 of the contract price which will be $2535 75/100, which is the last payment according to contract making a total paid contractors for building this said Bridge $10143.00/100. All the members expressing themselves that this said bridge was entirely satisfactory.

A few more minor subjects on streets were advocated and discussed but no action being taken the subject was laid over to some future meeting adjourned.

C.W. Chapman. President

Attest Sidney J. Beard
Clerk.

Figure 5: August 13, 1903 Minutes from the Nevada City's Board of Trustees Meeting approving payment for completion of Gault Bridge

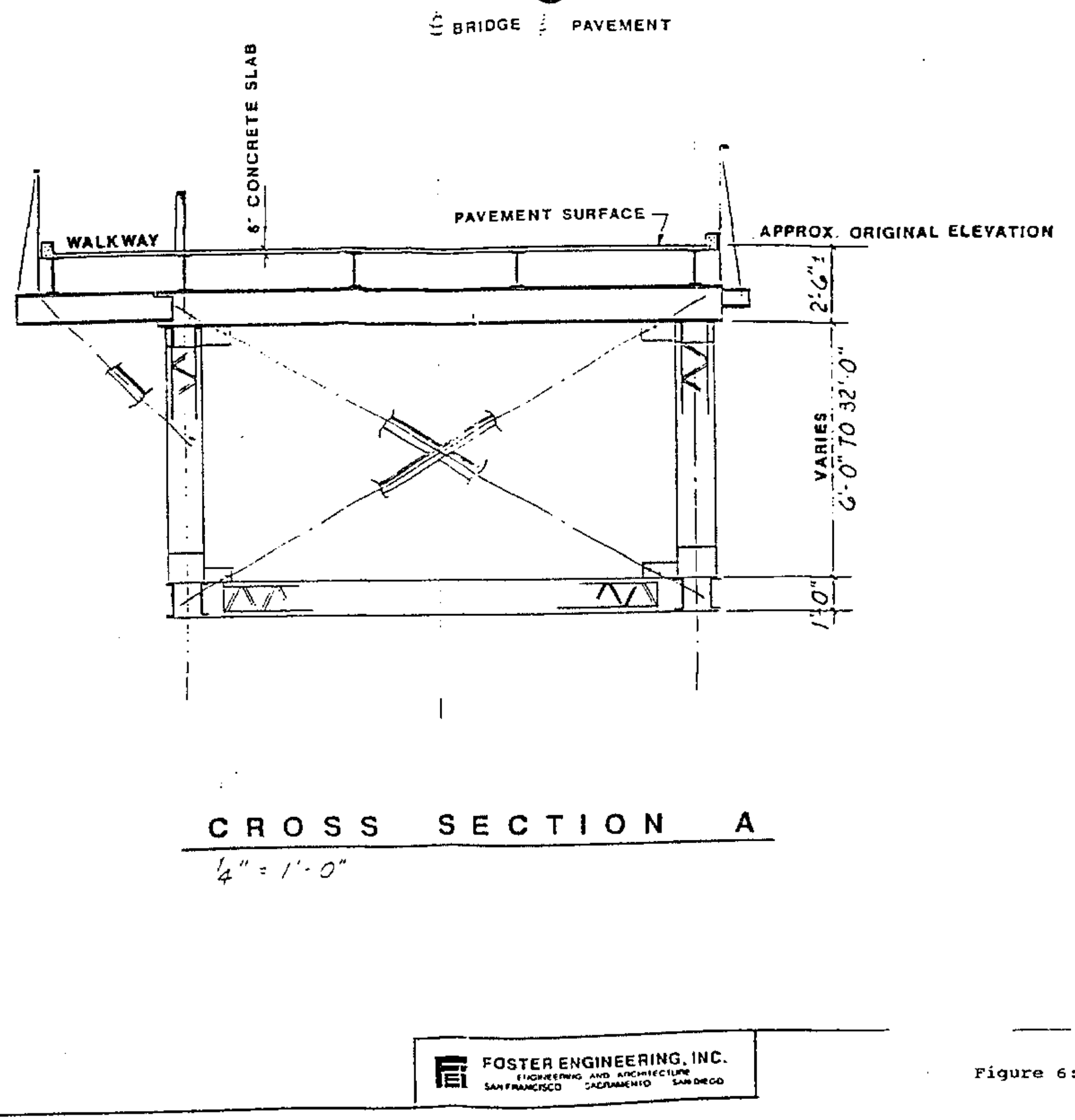

Figure 6: Cross Section of Gault Bridge showing cantilevered sidewalk constructed in 1941.

III. Sources

A. Original plans and specifications: None of the original plans and specifications for the Gault Bridge have survived. Apparently, Nevada City never received a set of plans for the bridge from the American Bridge Company. A 1928 California Division of Highways inspection report on the bridge indicates that a state engineer met with the Nevada County surveyor, W.W. Waggoner, who had copies of the original stress sheets and specifications for the bridge, but no plans. An old Nevada County Department of Transportation file on the Gault Bridge burned in a warehouse fire in September, 1994.

B. Historic views: Historic photographs of the Gault Bridge are in the Searles Library, Nevada City, California and in the private collection of historian Robert Wyckoff, Nevada City, California. A particularly good early view of the Hallidie suspension bridge is in the collection of the California Historical Society Library, San Francisco.

C. Bibliography

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May 14, 1902
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May 14, 1903
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August 13, 1903

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"Beginning of Active Work," May 12, 1903, page 4.
"Progress of Bridge Work," May 14, 1903, page 4.
"Votes Officially Canvassed -- First Payment on Bridge," May 15, 1903, page 4.
"Contractors Complete Their Work," July 19, 1903, page 6.
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IV. Project Information

This Historic American Engineering Record documentation of the Gault Bridge was undertaken because the City of Nevada City, the California Department of Transportation and the Federal Highway Administration are proposing to replace 95% of the existing Gault Bridge with a new structure that will replicate the three-hinge arch design of the existing bridge. The same alignment along South Pine Street will also be used for the new bridge. The 5% of the existing bridge that will be reconstructed on the replacement bridge is the decorative railing and newels along the east and west sides of the bridge roadbed.

Replacement of the Gault Bridge has been proposed because the bridge is substandard with regard to various loading combinations required by the American Association of State Highway and Transportation Officials. A study of the bridge by Foster Engineering concluded that "the level of corrosion had advanced to a point where the structural adequacy of several key elements was very questionable when subjected to full live load conditions." Analysis of alternate loading conditions determined the bridge could safely carry 20% of the standard 3-ton (H-3) limit with the provision that traffic be limited to two cars per lane on the bridge at any one time. Traffic on the bridge has been restricted to one car per lane since this analysis was completed.